Spacesuits need a major upgrade for the next phase of exploration

March 7 2024, by Yang Gao

The xEMU prototype Moon suit, unveiled by Nasa in 2019. Credit: NASA / Joel Kowsky

Humans have long dreamed of setting foot on the moon and other planetary bodies such as Mars. Since the 1960s, space travelers have donned suits designed to protect them from the vacuum of space and

stepped out into the unknown.

However, the Polaris Dawn mission, which is to include the first spacewalk organized by a private company, has been delayed. This is due to complications with the design and development of a suitable spacesuit.

Moon suits are also one of the key elements of NASA's Artemis lunar program that have yet to be delivered. A report released in November 2023 said that the contractor making the suits is having to revisit aspects of the design provided by NASA, which could introduce delays.

Yet the first spacewalk, by the Soviet cosmonaut Alexei Leonov, took place in 1965. Later, 12 NASA astronauts would walk on the lunar surface, between 1969 and 1972, using technology that would be eclipsed by today's smartphones. So it's not unreasonable to ask why it can still be difficult to design and build spacesuits to do the same thing.

Much has changed since the Apollo missions planted flags on the moon. The geopolitics driving space travel have shifted, and spacesuits are no longer expected to be just a form of protection. Instead, they are a critical way to improve the productivity of astronauts. This involves a rethink of not just the suits themselves, but the technology that supports them.

An array of powerful telecommunications technologies to connect astronauts with space stations and ground control sits alongside multisensory cameras, temperature readers and proximity sensors in present-day spacesuits.

Situational awareness—understanding key elements in the environment, such as the health of an astronaut—is a core tenet for modern spacesuit design and critical for the operator's safety. The ability of a suit to track

heart rate and other vital signs is important in a vacuum, where levels of oxygen need constant monitoring.

Expectations around the risks astronauts take have changed for the better. And the level of investment it takes to produce a spacesuit necessitates that it can be used for future tasks that may include lunar settlement in the next few decades.

The trade-off that engineers must make when incorporating wearable technology like those already mentioned is weight. Will greater situational awareness result in a spacesuit that is too heavy to move in effectively?

When Elon Musk first hinted at challenges with the extravehicular activity spacesuit for Polaris Dawn in a presentation to SpaceX employees in January, it was not difficulties with connected technology that he discussed, but of redesigning "the suit so that you actually move around in it."

The Polaris Dawn mission uses modified version of the Crew Dragon spacecraft to perform the first commercial spacewalk. Credit: NASA

Situational awareness

However, when talking about mobility in a spacesuit, you need to consider the tasks that you want that mobility to support.

Before the advent of modern spacesuits, Apollo astronauts struggled to carry out missions. When drilling into the surface of the moon with a hand drill to collect samples, astronauts found it difficult to provide enough downwards force to counteract the moon's weaker gravity. It was not until the invention of a zero-gravity drill, decades later, that this problem would be addressed.

The current exploration of pneumatic exoskeletons, providing the support necessary for movement in low gravity could be part of a solution. However, newer spacesuits may also need to interface with hardware, like robotic drills that exist outside the suit. This will also necessitate more mobility in spacesuits.

Working with robots

Offloading tasks, previously carried out by humans, to robots will be part of the future of space exploration. It's a primary way that engineers will also be able to enhance the mobility of astronauts in spacesuits.

For example, when an astronaut goes on a spacewalk to inspect the condition of part of a space station and make any possible repairs, they are supported by a robotic arm that ensures they don't float off into space. While jointed, this arm is rigid and can limit an astronaut's movement.

An approach currently being explored to extend this range of movement is a climbing robot, that is attached to both the astronaut and the space station, that an individual can control through their spacesuit. This would allow the astronaut to move around the space station faster and with a greater range of movement than before, allowing them to reach and repair hard-to-access areas like corners.

While the eventual hope is that robots themselves can assess any damage to the space station and repair it, due to possible disruptions in normal operations, humans must be ready to step in. Possible disruptions could be natural, like a small meteor shower damaging the robot, or human-made, like hacking carried by a hostile group or state.

For the types of activities we want to accomplish in the future, this human-robot collaboration will be instrumental. Building a base on the

moon, as both the U.S. and China plan to do, will involve construction work and drilling, which humans will not be able to accomplish alone. Modern spacesuits will need to provide an interface to work with this new technology, and we can expect the suits to evolve in step with robotics.

The relationship between humans and robots is changing. It will go beyond spacewalks and robots' previous uses as limited tools, to a situation where they are cooperative partners in space. The objectives of ten or 20 years from now, like building lunar settlements, exploring mineral deposits on the moon and efficiently repairing space station modules can only be achieved using robotics.

Modern spacesuits will be a key foundation of this collaborative relationship, forming the interface where astronauts and robots can work together to achieve shared goals. So when we do once again leave our footprints on other worlds, we will no longer be alone.

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